average, while the combined winter and spring accumulations reach over 180°. The graphs for the other stations, however, present no such marked accumulations.

The composite graph for all stations shows several interesting features. It will be noted that the range of temperatures on this graph has been increased to twice that on the others in order to give greater detail. The year 1921 immediately stands out as abnormally warm, with large positive accumulations for all seasons. No other year of the series shows such mild weather, while 1920 indicates that it was a generally cool year, except for the autumn.

A general survey of the composite graph indicates that the past 10 years have been mild, on the whole, except 1920, and, with the exception of 1929 and 1925, the winters have also been rather mild. Springs also show a tendency toward mildness, while summers apparently are close to normal. Autumns are also mild, especially 1921, 1922, and 1927. It would seem, therefore, that the claim that the past 10 years have been rather mild is substantiated by the evidence presented.

This paper was prepared at the suggestion of Mr. J. B. Kincer and the author is indebted to him for helpful suggestions and criticisms. Acknowledgment is also made of the valuable aid rendered by Mr. H. D. Wilson in preparing the graphs.

THE COOPERATIVE OBSERVER[1]

By CLARENCE J. ROOT

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The contribution of the United States Government to the climatological service of the world consists of more than 200 first-order weather stations, with their trained personnel, and nearly 5,000 cooperative observers. The cooperative stations have been established in nearly all parts of the country, and even extended into Alaska, Hawaii, and Porto Rico. The reports from these stations are in great demand. They are used by attorneys in legal proceedings, by those seeking new locations on account of business or health, by engineers in irrigation, reclamation, water supply, sewerage, drainage, and construction projects, by meteorologists, and others in the study of climates, by agriculturists and manufacturers, the latter in locating and operating plants, by shippers, railroads, and insurance companies in settling loss and damage claims, and locally by the public through the newspapers or by inquiry from the observer.

I can not say too much in praise of these public-spirited citizens who serve as cooperative observers. With some the weather is a hobby, others are interested in science, but with many it is the desire to contribute, and they carry on day after day, month after month, and year after year. Many of these observers are leaders in their communities; the others are serious-minded citizens, doing their bit for town and country, and it must be remembered that all have their vocations by which they are furnished a livelihood, and that Weather Bureau work is a secondary consideration. There are few organizations that secure so many men and women who render such high-class service without remuneration.

The writer has been engaged in climatological work over a period of 24 years and has known many cooperative observers. All of this experience has been in connection with the Illinois section and the remarks that follow must necessarily pertain to the service in Illinois.

When the climatological service was reorganized in its present form in 1895 the Illinois section was placed under Prof. Willis L. Moore at Chicago, with Charles E. Linney as assistant director, but in a few months Mr. Linney was made director. Prior to 1895 the work had been handled at Springfield by Col. Charles F. Mills, a State official, and John Craig, Government observer. In 1899 Mr. Linney brought the service back to Springfield and in 1900 he was succeeded by Montello E. Blystone. William G. Burns relieved Mr. Blystone January 1, 1903, and Mr. Burns turned the work over to the present section director in 1911.

In discussing personnel mention should be made of some of the old-time observers. The oldest continuous original record on file at the Illinois Section center is that begun by the late Dr. J. O. Harris and continued by his daughter, Emily H. Merwin, of Ottawa, Ill.

Dr. J. O. Harris was born in New York State in 1828. He served in the Civil War as assistant surgeon of the Fifty-third Illinois Infantry. His labors in the meteorological field date back to 1853, when he acted as correspondent for the Smithsonian Institution. Doctor Harris was a voluntary observer from 1870 until his death at Ottawa in 1905, when his daughter succeeded him.

Friedrich Brendel, M. D., came to this country from Bavaria in 1850 and settled in Peoria in 1852. His records of temperature and rainfall began in December, 1855, and continued practically unbroken for 50 years, the official connection with the Weather Bureau ceasing with the establishment of the regular station at Peoria in 1905. Doctor Brendel was a physician of excellent standing, a botanist of note, author of a 90-page pamphlet entitled "Flora Peoriana," a man of scientific tastes, and of deep devotion to his work. It is related of him on the best of authority that in his later years, while seriously ill and lying apparently unconscious, he would still rouse regularly about the observation hour and direct the nurses to read the thermometers. Doctor Brendel's death occurred August 10, 1912, at the advanced age of nearly 93 years.

The most remarkable substation record in Illinois is that of John West James in Riley Township near Marengo. Mr. James moved to Illinois from New York in 1860, beginning his work as voluntary observer for the Smithsonian Institution in that year and continuing almost without interruption until his last illness in 1917, thus completing a gratuitous service of 57 years. This is the longest record by any cooperative observer in the State, and probably one of the longest in the United States. The entire record was made on the same farm, so far as the writer knows without change of location, and during the entire 57 years not a single month was missing. Mr. James was a student of astronomy and meteorology, and his weather reports were considered practically infallible. It is recalled that when the writer first met him in 1911 he confessed that he had missed a few days back in the seventies and he wished to know if that was very bad. He was a single man, living with relatives who were inclined to ridicule his interest in science but he continued the work nevertheless until called by death.

Whittaker Holden came from England. He began keeping the weather records at Aurora, Ill. in 1879, and continued until his death in 1913, a period of 34 years. He had collected an interesting group of aneroid barometers, and on one of his trips had brought back from Eng-

[1] Presented before American Meteorological Society, Des Moines, Iowa, Dec. 28, 1929.

land a bed hygrometer. The climate of England is damp and hotel rooms in many cases are not heated. Now to those who are not familiar with bed hygrometers explanation is made that this instrument is placed between the sheets to determine whether the bed is dry enough to occupy. Mr. Holden loved his weather work and the instruments he had in his possession. A few moments before he passed away he asked his daughter to bring his favorite barometer and he died with it in his hands. The daughter, Miss Alice M. Holden, took up the work, at first because she knew it would have pleased her father to have the records continue. She has rendered splendid service over a period of 16 years.

Of the present observers the three with longest service are O. C. Nussle, Walnut, Ill.; Prof. F. U. White, Galva, Ill.; and Prof. H. N. Pearce at Bloomington, Ill. Mr. Nussle is a druggist, with 39 years to his credit. He is only 67 years of age and we expect him to maintain the Walnut records for some years to come. Mr. White has served the Weather Bureau 38 years but he has been superintendent of schools at Galva even longer, a unique distinction for a school man in a small place. He is unusually active for a man of 71. The Bloomington station was taken over by Mr. Pearce in September, 1899, more than 30 years ago. In January, 1927, his health failed, but he was unwilling to give up the weather work and Mrs. Pearce has kindly cared for the observations since then. For many years he was a chemistry instructor in the Bloomington High School.

These are human interest stories that serve to illustrate the faithfulness and loyalty of the cooperative observer.

We are justly proud of our associates out in the State, both for the high quality of the work, and the promptness with which their reports are rendered. It is not believed that any voluntary service, in or out of the Weather Bureau, produces work of higher quality than that of the Illinois observers. In two consecutive years observations were lost for only one month at a single station. Of the nearly 900 reports due at the section center during the first eleven months of this year 97 per cent arrived before the 6th of the following month, the bulk of them on the 1st, 2d, and 3d. But seven reports were received after the 7th.

In order to secure a climatological service of the best type, it is obvious that an intelligent personnel is needed. To a certain extent the condition will correct itself by a process of elimination. The poor observer will lose interest and quit, but the efficient one will become more and more interested in his work, especially if encouraged, and will continue on for years. In making appointments we ascertain the applicant's age and occupation, find out something about the place available for the exposure of the instruments, and endeavor to have him properly recommended.

Considerable attention has been given in Illinois to the location and distribution of substations. As opportunity presented, areas not properly represented have been cared for and stations too close together have been eliminated or changed from full cooperative to precipitation only. In a number of instances they have been brought from farms to the residence districts of towns, thus facilitating mail service. With proper geographical distribution always in mind, an effort has been made to locate instruments in important towns or cities or at railroad junctions—places where there is a demand for the records. The awkward situation by which at times the weather station and postoffice have had different names has been entirely eliminated.

It must not be assumed that having selected a suitable personnel and properly arranged the stations the service will move forward by itself. The work of the section center has just begun. There are long years ahead of what the chairman of our program committee terms "encouragement for cooperative observers." What then?

The word "cooperative" has been hard worked in Illinois. The observers are doing their part in taking the observations and preparing and mailing the reports, accurately, promptly, and regularly. If we at the section center have contributed anything toward this cooperation it has been largely through personal contact. This personal contact, the writer believes, is the most important element in conducting a climatological service. The Weather Bureau desires accurate reports from the substation observers, neatly prepared, and promptly forwarded. We, at the section center, must guide and advise these volunteers. Can we do this successfully with strangers?

In Illinois the section director does practically all of the inspection work, not because he can do it better, but the observers in the field look to him as the responsible head of the service and desire to meet the person with whom they feel they are cooperating. An effort is made to visit the stations every three years or to adhere to that policy as closely as possible.

We endeavor not to be too hasty in our substation inspection work. It does not require much time to look over the instruments and give the observer brief instructions, but is that enough? In our inspection work we average a station a day for the full cooperative stations and a little less time for the precipitation stations. This includes rail travel.

Very often the observer, because of his regular work, is not available until late in the day. In the meantime the inspector tests and cleans the thermometers, including the metal backs, cleans and oils the support, tests the rain gage, arranges for repairs, and prepares the inspection report and the report of Description of Station and Instruments, making new measurements if any changes have taken place since the last inspection. Then when the observer is free we have a good visit and go thoroughly into the observational work, but do not talk about the Weather Bureau exclusively.

On several occasions observers have remarked that if Uncle Sam takes the trouble to send an official to cooperative stations their records must be of importance. This idea encourages them to renewed interest in the work and is another argument in favor of frequent and regular inspections.

A section director who goes out in the field and becomes acquainted with the observers in their home surroundings is in a position to aid and encourage them in many ways, and thus secure that good will that results in efficiency and makes the work more agreeable for all concerned.

In the Illinois section there are 2 observers who have each served 35 years, several have served more than 25 years, and 19 in excess of 15 years. The older ones have been visited by the present section director four times and many others three times, and of the 81 in the State there are only 8 that he is not acquainted with personally. Naturally we have become friends, and when we ask a favor, such as improvement in the reports or earlier mailing, the observer is glad to comply, and he in turn knows that we will do what we can to produce cooperative conditions that are pleasant and interesting.

In the correspondence with the substations in the field the men at the section center endeavor to not only be courteous, but to show a friendly interest. For several

years we issued a little "length of service" pamphlet and a list of the veterans is published once each year in Climatological Data. Copies of Tycos and the Bulletin of the American Meteorological Society are passed about among the observers and publications are sometimes secured from the central office for distribution.

And so it is seen that hearty cooperation is necessary in the successful conduct of a climatological service and personal contact is probably the most important element in attaining that cooperation.

ARE PRESENT METHODS IN COOPERATIVE CLIMATOLOGICAL WORK EFFECTUAL?

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Some difficulty was experienced in choosing for this brief paper a title that would indicate exactly the things the writer had in mind to discuss; and since the title was submitted some doubt has remained in his mind as to whether it carries his meaning. Therefore, at the outset permit him to say that there is no intention of reflecting upon the character of the service rendered by the cooperative observer, nor in any manner whatever of impeaching his weather record. His importance in the field of climatology, and his public spiritedness and devotion to duty without compensation, oftentimes under trying circumstances, are highly appreciated by the great body of investigators who reap the benefit of his labors, but are appreciated by none more than by the officials of the Weather Bureau so closely in contact with his work. Nevertheless, in passing it may be said that the cooperative observer par excellence is, at least in some sections, becoming more and more a rara avis, and consequently the maintenance of satisfactory cooperative weather stations in such sections is becoming likewise more and more difficult. This is especially true of the more populous and urban regions. This situation was recognized by the director of the Iowa climatological section, and was commented on by him in his report for January, 1928. It has also been the experience of the writer in his work in the Indiana climatological section. The causes, however, have nothing to do with the purpose of this paper, and may, therefore, be left for possible future consideration.

As there is no intention of reflecting on the work of the cooperative observer, also neither is there any intention of intimating that the presentation of climatological data as published by the Weather Bureau in its several section monthlies is of other than very great value to the bureau itself as well as to many and varied interests and professions. The ever increasing demand for such data by these industries and professions is proof positive of the important service performed in securing and distributing climatological information.

However, if there be in the observations, records, and subsequent publications, any matters that may be more accurately interpreted, or presented to better advantage, such matters, even though of minor importance are worthy of some consideration. In the course of nearly 20 years of practice in the inspection of cooperative climatological data and of preparing the same for publication there have arisen in the mind of the writer two general questions, each with several separate divisions:

(*1*) As to whether in the inspection and final summarizing of cooperative records at the section center certain corrections or adjustments before publication are desirable; and,

(*2*) As to whether the climatological data presented in the printed section monthlies could to advantage be curtailed, added to, or changed in any respect.

As to the first of these general questions, extended comparison of Indiana cooperative data with those of the regular Weather Bureau stations within and near the section boundaries, as well as similar though less extended comparisons of the data in other sections, has lead to the following conclusions, which are submitted with some comment thereon:

(*a*) That for much of the country, cooperative records usually average a greater number of days with maximum temperatures of 90° and higher, and also a greater number of days with minimum temperatures of 32° and lower, than do the records of the regular Weather Bureau stations in and around the same section. Why is this and what is the effect, if any, upon the mean temperature computed for the section?

It will be recalled that the meteorological day at the cooperative station usually ends at some afternoon hour near sunset or earlier, and that the temperature readings then obtained are for the preceding 24 hours. As the highest temperature of the day occurs most frequently during the early to late afternoon, it is naturally to be expected that days of any maximum temperature chosen for count will be recorded in greater number at the cooperative station than will be the case at the regular Weather Bureau station where the day closes at midnight. In other words, the maximum temperature of a single calendar day, by reason of the fact that it usually occurs in the afternoon, is often carried into the cooperative record as the maximum temperature of two days instead of one; so increasing the total number of days of certain high temperatures, and also increasing slightly the mean maximum temperature computed for that particular month.

The cause of the recorded larger number of days with minimum temperature of say 32° or lower at many cooperative stations—not so many more, however, as is the case with high temperature records—is different. Except at the comparatively few cooperative stations taking observations in the morning at about 7 a. m., the hour of the cooperative observation has little effect on the number of such days recorded. Most of the regular Weather Bureau stations are in the central business sections of the larger cities, where the minimum temperature that usually occurs during the late night or early morning is held up somewhat by the greater heat of large buildings and pavements, and by the effect of overhanging smoke in hindering radiation of heat. On the other hand, cooperative stations usually have a much more open exposure, and even if located in the large cities are most often to be found in the outlying residential sections. In such places the fall of temperature through the night to its minimum is not retarded by the conditions mentioned in the preceding sentence; and so, consequently, the cooperative station more often records a low temperature of say 32° or lower than does the regular Weather Bureau station.

As the greater number of days with high temperatures recorded at cooperative stations must result—and improperly so—in an erroneous idea of the frequency of such days in that locality, and a slightly higher mean monthly maximum temperature than should be the case,